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Safety Culture Promotion Intervention Program (SCPIP) in an oil refinery factory: An integrated application of Geller and Health Belief Models

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ABSTRACT

As the most of work-related accidents results from unsafe behaviors, there is clearly a need for research in this area. The purpose of this study was to assess safety culture among operation personnel of an Oil Refinery Company (ORC) in Tehran and design and implement a Safety Culture Promotion Intervention Program (SCPIP) based on an integration of Geller and HBM models. In this quasi-experimental study, as the first phase, 190 operational employees of an ORC were recruited. The data were analyzed and the SCPIP was designed. In the second phase, 90 employees were elected for the intervention (45 for the experimental group and 45 for the control group). The evaluation of SCPIP was conducted 2 months after intervention. The environmental factors were in a good condition. About 44% of the behavioral factors and about two thirds of the cognitive factors were rated as moderate/weak. Before intervention, there was no significant difference between the two groups by the total cognitive factors and the HBM constructs. After intervention these differences were significant ($p \leqslant 0.001$). After implementing the intervention in the experimental group, the HBM total score was remarkably improved (Mean Difference = 11.25, t = 10.100, $p = 0.001$). The integrative application of the Geller and HBM Models was helpful in assessing the cognitive predictors of safety culture among the personnel of the ORC. SCPIP was useful in improving the employees' perceptions on safety culture in the occupational setting. HBM may be utilized to promote the human component of Geller model.

1. Introduction

In the Heinrich study in 1931, it was concluded that 88% of the industrial accidents occur as a result of people's insecure performance (Department, 2002; Stringfellow, 2010). Industrial accidents are unexpected events causing damage and injury to people, their properties and consequently the societies (Kjellén, 2000). According to the International Labor Organization (ILO) report (2016), every day about 6300 people die as a result of occupational accidents or work-related diseases. Occupational accidents, also, result in more than 2.3 million deaths per year (ILO, 2016). These accidents have a multidimensional burden for societies. The human costs associated with such incidents result from the loss of manpower, materials, equipment and time, which are above 5 million dollars per year (Harms-Ringdahl, 2003). Based on the estimation of ILO, the annual economic burden caused by poor occupational safety and health practices is about 4% of global Gross Domestic Product (ILO, 2016).

The term "Safety Culture" was firstly used in a nuclear report in 1987 on the Chernobyl disaster (Gibbons, 2007). The report showed that the adverse events were mostly preventable (Flin, 2007). The UK Health and Safety Commission defined the term as "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management" (Kaafarani et al., 2009). Safety culture is something in which everyone is concerned about safety issues (Bodur and Filiz, 2009). An organization with a promoted safety culture encourages all level individuals and groups to be both active and accountable in the following areas: predicting and managing risks and threats for global success, developing and enhancing safety and improving operation, effectiveness and production (Taghdisi, 2009).

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Safety culture appears when it is perceived by all the employees as a key value in a given organization (Roughton and Mercurio, 2002). It is a complex structure in every organization which includes the existing safety attitudes, values and behaviors in the organization, most of which are potentially modifiable factors associated with the real accidental behavior. Wu et al., believed that the quality of safety culture is directly affected by the safety of individuals (Ooshaksaraie et al., 2009; Wu et al., 2009). Creating safety culture through modifications in the incentives of individuals without taking into account the occupational and organizational factors as well as the interaction of psychological and behavioral factors seems to be failed (Heidari et al., 2007). Good design and implementation of safety behavior intervention processes can positively affect the movement of an organization towards safety culture. Taking into account the internal cognitive factors related to behavior is also important (Gilmore et al., 2002).

In industries, safety is considered as an important issue and a key priority. As the most of work-related accidents results from unsafe behaviors (Salminen and Tallberg, 1996; Seo, 2005), there is clearly a need for research in this area. Also, since the behavior of workers is involved in many industrial events, educating them about the workplace hazards and how to manage the risks may increasingly improve their health and safety (Zalewski, 2005).

Nowadays, health education researchers apply behavior change theories of psychology and social sciences to design patterns that are useful and effective in adopting safe behaviors among different populations (Glanz et al., 2008). Theories and models in the various stages of planning, implementation and evaluation of an intervention are beneficial and helpful in understanding the nature and explaining the dynamics of health behaviors (Noar and Zimmerman, 2005).

1.1. Geller's Total Safety Culture Model

Geller's Total Safety Culture Model (Geller, 1994, 1996), known as Geller Model and one of the basic "safety triad" models for safety culture promotion, proposes that in order to design an effective safety promotion program, three major factors should be considered; human (such as the knowledge, beliefs, values, motives, abilities and personality of individuals), behavior (like complying, coaching, recognizing, communicating and demonstrating the active care) and environment (such as equipment, tools, machines, housekeeping and heat/cold engineering) (Sukadarin et al., 2012; Fedorycheva and Hammer, 2015). This model is based on the continuous monitoring of these three dimensions, which are assumed to be dynamic and capable of influencing each other. In this way, when an individual choose to work safely, he/she have to think in this regard and ultimately have to be led to develop the safe behaviors and to make changes in the environmental conditions (Guldenmund, 2000). Fedorycheva et al., in a review on the safety triad models of safety culture noted that the triad models like the Geller Model have made the quantifying of safety culture possible in a meaningful way at various organizational levels. They also noted that incorporating all of the facets of safety culture in a framework is rare and even defining a methodological approach for applying the framework in an industry setting is rare. In the present study, the authors tried to design a methodological approach to not only apply all the components of Geller Model, but also to promote the human component of the model utilizing Health Belief Model (HBM). In Geller Model, the cognitive factors as the constituents of human component play a substantial role in developing the safety culture among individuals. Therefore, in order to study the cognitive factors in a more systematic way, we hypothesized that an integration of Geller model and HBM may result in more success in promoting safety culture of an industrial setting.

1.2. Health Belief Model

Health education and promotion specialists usually apply theory and model-based interventions aiming to change behavior in different settings. The Health Belief Model (HBM) (Hochbaum et al., 1952; Janz and Becker, 1984) is one of the most widely used behavioral change models focused on the cognitive determinants of behavior (Rosenstock et al., 1994). This model suggests that individuals conduct an internal assessment to find out the net pros of changing their behavior, and finally decide whether or not to act (Green and Murphy, 2014). Four domains have been considered for such assessment: perceived susceptibility to a disease or health risk, perceived severity of ill-health, perceived benefits of changing behavior, and perceived barriers to perform the healthy or safe behavior. Based on HBM, if one believes himself as a susceptible person to a specific health problem, he will probably become more sensitive toward it, consider it as a serious issue and consequently accept the preventive behaviors. Indeed, the individual should be convinced on the affordability and effectiveness of those behaviors in preventing ill-health. As HBM has been successfully used to predict and promote the cognitive determinants of various behaviors among individuals in different settings (Carpenter, 2010; Mehri et al., 2011; Zhang et al., 2013; Cao et al., 2014; Cheraghi et al., 2014; Harris, 2016), it was assumed to be applicable for covering the human component in the Geller Model, as well.

The purposes of this study were to (1) assess safety culture in an ORC in Tehran applying the Geller model, (2) assess the applicability of HBM in covering the human component of Geller Model and (3) design and implement a Safety Culture Promotion Intervention Program (SCPIP) based on an integration of Geller and HBM models aiming at safety culture promotion in the ORC in Tehran.

2. Methods

2.1. Study design

This controlled quasi-experimental field trial was conducted on operation staffs in an ORC in Tehran, Iran. The study was conducted in two phases: at the first phase, the safety culture of the ORC was assessed using the Geller and HBM models, which served as a needs assessment for the second phase of the study. In the second phase, based on the findings of the needs assessment, the SCPIP was designed and implemented through a controlled quasi-experimental intervention in the company.

2.2. Instrumentation

The instruments used for the first phase of the study included a Demographic Characteristics Form, a Safety Culture-related Cognitive Factors Questionnaire (SCCFQ), a behavioral and an environmental checklist.

All abovementioned questionnaires and checklists used within the study were developed by the authors after a review of the relevant literature (Heidari et al., 2007; Sanaenasab et al., 2008; Nouri Parkestani et al., 2010) and consultation with scholars in the field. Then, the questionnaires were pilot-tested and found suitable for the purposes of the study.

A panel of experts, consisting of three scholars in the areas of health behavior and education, an occupational health specialist, an epidemiologist, a psychologist and an HSE (Health, Safety and Environment) expert with field experience in safety promotion, reviewed and assessed the questions, orally, by evaluating the appropriateness and relevance of the items to the ORC staffs and the response format. The panel, also, confirmed the items to be representative of the constructs in order to confirm content validity of the instruments. The feedback from the experts was

used to revise and modify the instruments. The feedback was mostly regarding the wording and phrasing of the questions. Then, the instruments were pilot tested by a sample of operational staffs to examine their utility and to identify the problems/benefits associated with the design. Following consultation with the multidisciplinary team, the first draft was prepared. The questionnaires were then pilot-tested with 30 operational staffs not included in the final study. The data were used to estimate the internal consistency of the scales, using Cronbach's Coefficient Alpha. The content validity of the scales was also established. Table 1 illustrates the scales, number of items, possible ranges of the scales as well as the reliability coefficients in the pilot and final sample.

The SCCFQ (Appendix A) was developed based on the HBM. It comprised the cognitive constructs including perceived susceptibility, perceived severity, perceived barriers, perceived benefits, and cues to action. All the scales were rated based on a five-point Likert-type scaling (ranging from 1 = totally disagree to 5 = totally agree). The only exception was for Cues to action scale, which had a Yes/No answer format. All the items of SCCFQ scales were then summed to acquire a total score for the human construct of the Geller Model.

The Environmental Checklist consisted of 120 items based on a four-point scale (good (3), moderate (2), weak (1) and irrelevant (0)). Examples of the items are presented in Appendix B.

The Behavioral Checklist, also, comprised two separate sections; one for repair employees (49 items) and one for operational staffs (27 items). The response format for the items was considered to be Yes (2)/No (1) choices. Examples of the items are presented in Appendix B.

2.3. Sampling and data collection

In order to conduct the first phase of the study, a sample size of 190 operational staffs were recruited to participate in the study. After coordination with the administrators of the ORC, informed consent was obtained from the respondents and all signed consent forms. They were also explained about the purpose of the study and assured on the confidentiality of their information. Along with data collection, applying the self-administered SCCFQ, from the sample, the behavioral and environmental checklists were also filled out based on the observations conducted by the first author.

For the second phase of the study, quasi random allocation technique was used to divide the sample into experimental and control groups. As the ORC included two units (Northern and Southern ORCs), it was decided to elect the staffs for the experimental group (n = 45) from the northern and for the control group (n = 45) from the southern unit. The intervention was implemented on the experimental group during 1 month (May 2014).

2.4. Safety Culture Promotion Intervention Program (SCPIP)

Based on the results of analyses conducted in phase 1, the problem and weak points of the ORC regarding safety culture were distinguished. The rating of the components of Geller Model based on a classification into good, weak and medium levels are presented in Table 2. According to this table, all of the environmental factors were rated as good or moderate, which showed that the ORC was in a fair to good condition in terms of the environmental factors. However, about 44% of the behavioral factors (in both divisions) and about two thirds of the cognitive factors were rated as moderate or weak. Therefore, it was decided to consider the cognitive factors as the focus of intervention, with the hope to promote the behavioral factors through implementing the intervention on the cognitive factors. The weak level of perceived susceptibility and severity toward unsafe behaviors were more common among the personnel. They, also, perceived a high level of barriers to perform safe behaviors at work. Based on these findings, the SCPIP was, designed and implemented in 2 sections as follow.

2.4.1. Safety culture education program

In order to train the staffs in the experimental group, group discussions on problem solving and adult learning principles techniques were used. This experimental group was divided into 6 groups of 8–12 staffs. A key content strategy for this educational program was consciousness rising on the causes and outcomes of unsafe behaviors and the methods of resolving the possible barriers toward safe working. Furthermore, applying self-reevaluation strategy, the staffs were provided with the role models on safe performance at work. In the training sessions, the observations and feedbacks of the respondents on the safe and unsafe working were discussed. Also, the role models in the bulletin were discussed to transparent the values of safety culture among the respondents. Program characteristics and key content areas of the educational program are shown in Table 3. During the educational sessions, it was tried to establish good relationships among the staffs and prepare them for an active participation in discussions in order to prepare them for learning, reconsidering their ideas, attitudes and changing their behavior.

2.4.2. Safety culture promotion program

In this part, a pamphlet and a safety promotion movie regarding the disadvantages of not compliance with safety culture and the advantages of safety culture compliance was prepared to help the staffs in promoting their cognitive processes about safety culture. In other words, in order to promote perceived susceptibility and severity among the staffs, threat enhancing strategies like expressing previous incidents due to failure in complying with the safety rules and showing short-time movies and cartoons on the process of happening a work accidents were used. Moreover, a weekly newsletter with safety culture topics (in 4 issues) was published in the company to increase the level of perceived threat toward unsafe behaviors and to decrease the level of perceived barriers toward safe behaviors among the personnel. Also, safety culture promotion posters and banners with specific focuses were installed in proper areas of the work sites (Table 3).

Table 1
Descriptive statistics for SCCFQ, and behavioral and environmental checklists.

All constructs	Mean (SD)	Number of items	Possible range	Cronbach α in the pilot study	Cronbach α in the main study
Perceived susceptibility	17.68 (2.23)	5	5–25	0.70	0.77
Perceived severity	17.88 (2.56)	5	5–25	0.68	0.74
Perceived benefits	26.96 (2.74)	6	6–30	0.70	0.80
Perceived barriers	26.13 (5.63)	7	7–35	0.80	0.89
Cues to action	–	2	13–65	0.87	0.83
Behavioral checklist					
For Repair Division	50.44 (13.33)	36	0–98	0.83	0.85
For Operation Division	49.07 (3.99)	27	0–54	0.87	0.81
Environmental Checklist	289.28 (29.76)	120	120–360	0.89	0.90

Table 2
The dimensions rating of the Geller Model.

Structure	Good		Moderate		Weak	
	N	%	N	%	N	%
Cognitive factors						
Perceived susceptibility	6	3.2	98	51.6	86	45.3
Perceived Severity	10	5.3	93	48.9	87	45.8
Perceived barriers	39	20.5	79	41.6	72	37.9
Perceived benefits	113	59.5	72	37.9	5	2.6
Behavioral factors						
For Repair Division	36	50	12	17.1	23	32.9
For Operation Division	75	62.5	32	26.7	13	10.8
Environmental factors	3	42.86	4	57.14	0	0

Table 3
Profile and key points of the proposed training program (SCPIP) for employees of the oil refinery factory.

Methodology/period	70 min sessions/6 sessions for 8–12 personnel
Training team	3-person team (occupational health specialist, HSE specialist, health education and promotion specialist)
Resources and costs required for SCPIP	A room for holding training sessions (in the units of operation), training costs and time spent by group training
Key strategies	Consciousness raising, Perceived thread raising, Self-reevaluation, environmental reevaluation, Role modeling
Key points	The essentials of safety culture, safety procedures in the factory, the need for action, the relationship between non-safe behaviors, accidents and work-related injuries, how to resolve the barriers of safe behaviors, the benefits of safe behaviors, and considering safety as an obligatory rule or a value?
The main processes of SCPIP	Experimental teaching methods (problem solving discussions, feedback sessions and activities), building safety culture in refineries to raise the perceived susceptibility (installed placards, posters, pamphlets prepared), publication of a safety bulletin to raise the perceived severity and perceived benefits and decrease the level of perceived barriers (expressed incidents due to failure to comply with safety principles, advantages and benefits of compliance with the principles of safety, lack of pride and overconfidence, awareness about safety issues)

Two months after implementing SCPIP, the questionnaires were again completed by the experimental and control groups.

2.5. Statistics

Data were coded numerically and entered into Statistical Package for Social Sciences (SPSS) software, version 17.0 for windows. Summary statistics and frequency distributions were used to describe and interpret the meaning of data. The differences between the Geller model and HBM constructs by demographic variables were analyzed using one-way ANOVA. Pearson correlation coefficient was applied to indicate the associations between HBM structures. Moreover, paired *t*-test was applied to illustrate the variations in the scores on HBM constructs before and after intervention. The level of significance was set to be less than 0.05, at the priori.

3. Results

The mean age of the respondents was 35.46 (SD = 10.68) years. The majority (62%) had diploma education and was married (75.5%). Nearly 30% of the respondents had a history of occupational accident and about 1.5% was little satisfied with their job. There was no significant difference between the experimental and control groups in terms of demographic characteristics (Table 4).

The mean score comparison of the cognitive factors (HBM constructs) in the experimental and control groups before and after intervention are shown in Table 5. Before intervention, there was no significant difference between the two groups by the total cognitive factors score and the HBM constructs, using *t* test, but after intervention these differences were significant ($p \leqslant 0.001$). Table 5 also illustrates the mean scores comparison of the HBM constructs before and after the intervention. After the intervention, there was found a significant increase in the HBM constructs' scores in the experimental group ($p \leqslant 0.001$). No significant difference was found in the HBM constructs' scores in the control group, except for perceived susceptibility ($p \leqslant 0.05$).

Applying paired *t* test, it was also found that after implementing the intervention in the experimental group, the HBM total score was remarkably improved, (Mean Difference = 11.25, t = 10.100, df = 44 and $p = 0.001$). No significant improvement was found in the control group (Mean Difference = 1.23, t = 1/48, df = 44 and $p = 0.154$) (Table 5).

4. Discussion

The aim of this study was to determine the effects of SCPIP on the safety culture status among personnel of an ORC in Tehran, applying an integration of Geller and HBM models. The results showed a non-significant increase in the level of total cognitive factors toward safety culture in the control group after two months. On the other hand, two months after implementing the SCPIP in the experimental group, the level of total cognitive factors toward safety culture was significantly increased from 90.6 to 101.9. These findings showed that the SCPIP was effective in improving the employees' perceptions on safety culture. Similar results were found by previous studies (Lippin et al., 2000; Taghdisi et al., 2005; Hazavehei et al., 2008; Sanaenasab et al., 2008) within which the perceptions of different populations in different occupational settings were investigated. Moreover, in a study on work-related accidents among construction workers, Dong showed that teaching safety principles had an important role in reducing the number of accidents (Dong et al., 2004). Also, lack of awareness and illiteracy can cause a feeling of irresponsibility towards health issues (Clark et al., 2000), and such irresponsibility toward health and safety may in turn result in a higher range of occupational accidents among employers.

In the present study, it was found that the SCPIP has had a significant impact on perceived susceptibility of the respondents. In other words, after intervention, the employees became more sensitive toward safety principles. They, also, perceived themselves more susceptible to accidents and injuries. Mehri et al., and Gerend

Table 4
Demographic characteristics of the employees in the first and second phases of the study.

Demographic characteristics	The first phase n (%) N = 190	p. value	The second phase		p. value
			Experimental Group, n (%) N = 45	Control Group, n (%) N = 45	
Age (yrs.)		0.035			0.836
20–25	27(14.2)		15(33.3)	13(28.9)	
26–33	69(41.1)		10(22.2)	12(26.7)	
34–40	19(10.0)		4(8.9)	6(13.3)	
41 and older	66(34.7)		16(35.6)	14(31.1)	
Marital status		0.054			0.590
Married	134(70.5)		31(68.9)	31(68.9)	
Single	56(29.5)		14(31.1)	14(31.1)	
Education		0.003			0.512
Under Diploma	16(8.4)		–	–	
Diploma	118(62.1)		32(71.1)	27(60)	
Technician	27(14.2)		8(17.8)	10(22.2)	
Bachelor	29(15.2)		5(11.1)	8(17.8)	
Work experience (yrs.)		0.042			1.0
1–5	84(44.2)		22(48.9)	22(48.9)	
6–10	25(13.2)		6(13.3)	6(13.3)	
11 years and more	81(42.6)		17(37.8)	17(37.8)	
History of occupational accident		0.978			0.319
Yes	56(29.5)		14 (31.1)	11(24.4)	
No	134(70.5)		31(68.9)	34(6.75)	
Satisfaction with Job		0.187			0.187
Low	22(11.6)		6(13.3)	8(17.8)	
Moderate	89(46.8)		23(51.1)	20(44.4)	
High	79(41.6)		16(35.6)	17(35.6)	
Employment status		0.000			0.386
Official employment	117(61.6)		39(86.7)	37(82.2)	
Contractual employment	40(21.1)		6(13.3)	8(17.8)	
Arbitrary employment	33(17.4)		–	–	
Cues to action		0.093			0.261
Management team	28 (31.07)		9 (20)	6 (13.3)	
Radio and Television	16 (17.75)		5 (11.1)	4 (8/9)	
Internet	14 (15.53)		4 (8.9)	5 (11.1)	
Unit supervisor	31 (34.4)		6 (13.3)	5 (11.1)	
Newspapers and journals	15 (16.64)		5 (11.1)	7 (15.6)	
Educational Hard Materials (Pamphlets, booklets, and posters…)	67 (74.35)		16 (35.6)	18 (40)	
No Cues to action	9 (10/1)		–	–	

Table 5
Mean score comparison of the total cognitive factors and HBM constructs before and after 2 months of the intervention between the two groups.

		Before intervention Mean (SD)	After intervention Mean (SD)	p. value
Total cognitive factors score[a]	Experiment	90.68 (7.5)	101.93 (4.22)	0.001
	Control	85.97 (7)	87.2 (6.1)	0.154
	p. value	0.807	0.000	–
Perceived susceptibility	Experiment	17.46 (2.1)	20.93 (2.0)	0.000
	Control	17.06 (2.1)	18.66 (2.0)	0.029
	p. value	0.382	0.000	–
Perceived severity	Experiment	18.97 (2.4)	22.26 (1.6)	0.000
	Control	17.35 (2.3)	17.55 (1.9)	0.587
	p. value	0.459	0.001	–
Perceived benefits	Experiment	27.15 (2.3)	28.66 (1.36)	0.000
	Control	26.17 (2.6)	25.68 (1.8)	0.249
	p. value	0.620	0.001	–
Perceived barriers	Experiment	27.8 (5.3)	30.0 (2.2)	0.001
	Control	25.3 (5)	25.88 (3.8)	0.493
	p. value	0.093	0.000	–

[a] Score range 0–100. Higher score represents a higher level of cognitive factors.

et al., in two separate studies compared HBM and Theory of Planned Behavior in predicting the determinants of safe behaviors. They finally reported perceived susceptibility as one of the most significant predictors of the behaviors (Mehri et al., 2011; Gerend and Shepherd, 2012). When perceived susceptibility toward ill-health in an individual is high, he/she is more likely to adopt the preventive behaviors. Successful risky behavior prevention depends on the real information of an individual about the level

of susceptibility toward the outcomes of the risky behavior (Hazavehei et al., 2008). In other words, if an individual becomes sensitive toward a risky behavior-related health issue and believes that he/she may suffer from its related disease without symptoms, then, the sensitivity can lead him/her to prevent the risky behaviors. Similar results were found by Babazadeh et al. (2016) who worked on the cognitive determinants of skin cancer preventive behaviors among rural farmers.

In the control group, the only significant difference in the constructs of HBM before and after intervention was found to be in the perceived susceptibility of the respondents. This finding may be due to the sensitivity created among the respondents in the control group by asking the pre-test questions regarding their susceptibility toward non-safe behaviors in the work setting. This group, after a period of time as an opportunity to think on the issue, may found themselves more susceptible toward the non-safe behaviors in the work setting.

Another finding of the study was the significant difference found between the mean scores of the perceived severity before and after conducting SCPIP in the experimental group, so that after the intervention, this group had a better perception on the severity of non-safe behaviors and also the seriousness of unsafe behaviors. Pender says that the perception of risk is significantly associated with behavior and its continuity (Pender et al., 2011). It means that if a given intervention focuses on the perceptions of the respondents on the risk factors, then, that intervention may be successful in preventing risky behaviors, as those found in the present study.

As another finding in the present study, a significant difference was found between the mean scores of the perceived barriers, in the experimental group, before and after the SCPIP. Some examples of perceived barriers included the belief in the obligation of destiny, chance of accidents, the role of physical factors (e.g. heat in the workplace), discomfort and sweating when using personal protective equipment and obsession to speedy working without paying attention to the safety issues. Similarly, Buller et al., in a previous study reported "warm clothing and perspiration" as the most commonly perceived barrier noted by the construction outdoor workers (Buller et al., 2005). In the SCPIP, based on the initial assessments, some barriers including insufficient training for the personnel and the role of management in forcing on quick work regardless of the safety issues were considered for intervention which consequently resulted in safety culture promotion among the respondents.

Comparing the mean scores of the two groups before and after the intervention showed that the perceived benefits score was in a relatively good condition in both groups before intervention. After intervention, the mean score of perceived benefits increased significantly only in the experimental group. International Nuclear Safety Advisory Group in a report on the key practical issues in strengthening safety culture noted that the employees' perceived needs for and perception on safety while doing any kind of job responsibilities has a decisive effect on their safety behavior (INSAG, 2002). Therefore, it can be concluded that defining the benefits of safety behaviors for the employees may help in adopting the safe behaviors.

In the present study, the mostly referred source of information regarding safety and safety culture for the employees was reported to be the educational and instructional materials provided in the company including placards, pamphlets, posters and bulletins. This finding emphasizes the important role of the training materials provided in the company. Thus, as considered in the SCPIP, providing a systematic mechanism aimed to delivering the most relevant and up to date educational materials in the factory environment is recommended to encourage employees in observing and following up the new safety rules and to establish a positive safety perspective in the company. The second referred source of information noted by the employees was the supervisors of the departments and the management team. These human sources may encourage and guide employees to adhere the safety culture. Similarly, Clarke emphasized on the role of supervisors in the exchanging of information between workers and managers (Clarke, 2006).

4.1. Limitations

There were limitations in this study. We tested the original version of HBM and for future studies we propose to test the applicability of the extended HBM - as some influential psychological factors like self-efficacy have been provided in the extended model. The respondents of this study were recruited only from one oil factory in Tehran. Therefore, inferences drawn from the results should be applied with caution.

4.2. Conclusions

Based on the results of this study, we can propose that in order to design effective educational programs, occupational healthcare professionals should better understand the determinants of safety culture among the personnel of the occupational settings and develop stage-specific interventions, within which promoting cognitive factors like perceived susceptibility and perceived barriers are priorities of the program.

The integrative use of the Geller and Health Belief Models was found to be helpful in assessing the environmental and cognitive predictors of safety culture promotion in the ORC as well as addressing the effects of the health promotion intervention (SCPIP) on safety culture among the personnel of the factory. It can be concluded that such an application of the health education and promotion models, as a framework for planning safety promotion programs, may be useful in improving employees' perceptions on safety culture in occupational settings. HBM was found to be helpful in promoting the human component of the Geller model.

Ethical approval

Ethical approval for the study was provided from ethical committee in Tehran University of Medical Sciences. The project Code: 90-02-132-12965. Informed consent form was completed and signed by all respondents.

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Conflict of interest

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Appendix A. Safety Culture-related Cognitive Factors Questionnaire (SCCFQ)

SCCFQ

Items	Strongly disagree	Disagree	No idea	Agree	Strongly agree
Perceived susceptibility					
1 In the future, it is likely that I have an accident at work					
2 I am a strong person and I will not have accident at work					
3 I am at risk for accident while working, even if I regularly comply the safety rules					
4 It is very likely for me to have an accident-related injury at my work					
5 Considering the specific environmental conditions of my division in the factory, I am not at risk as much as the others					
Perceived severity					
1 Non-compliance with the safety rules will cause in irreparable damages and costs to me and the company					
2 In our company, unsafe working may result in serious health consequences					
3 If I work without safety in the factory, my spiritual and mental health will be disrupted					
4 If I not follow the safety rules at work, my colleagues will blame me					
5 Safety equipment use while working will diminish the possible effects of harmful agents					
Perceived barriers					
1 Compliance with safety rules at work is time-consuming					
2 Brave and strong men never use personal protective equipment (like helmets, safety gloves and ...) while working					
3 Sometimes conditions such as heat or harassment resulted from safety equipment (like helmets, safety gloves and ...) hamper me to work safely					
4 Sometimes it is necessary to disobey the safety rules at work to increase the production rate					
5 In my opinion, work accidents depend on the chance of individuals					
6 Safe working results in slow progress of the jobs					
7 I think work accident is a result of fate					
Perceived benefits					
1 I believe that I can prevent work accidents by complying the safety rules					
2 All employees should know on how to use personal protective equipment					
3 In my opinion, discussing and exchanging the ideas with my colleagues about safe working is helpful to prevent accidents					
4 I believe that safe working does worth spending time					
5 Using appropriate and safe instruments while working is necessary					
6 It is necessary to continuously emphasize the safety issues at work					
Cues to action					
1 Have you ever received information on safety/safety culture at work?	Yes ☐			No ☐	
2 If Yes, please indicate the source(s) of your information?	Management team Radio and Television Internet Unit supervisor Newspapers and journals Educational Hard Materials (Pamphlets, booklets, and posters...)				

Appendix B

B.1. Examples of the items presented in the behavioral checklist

Behavioral checklist at work *For operation division*				
Examples of the items		Yes	No	N/A
1	Uses helmet			
2	Wears safety shoes			
3	Wears uniforms			
4	Wears safety gloves when needed			
5	Wears safety masks when needed			
6	Wears safety glasses when needed			
7	Wears anti-acid uniforms when needed			
8	Works in coordination with superiors			
9	Performs gas checking before every possible repair			
10	Before possible repair of an apparatus, inspects and disconnects all the entering lines of gas, steam or oil products into the device			
27	Stands at the right place while working with an apparatus			
Behavioral checklist *For repair division*				
Examples of the items		Yes	No	N/A
1	Uses helmet			
2	Wears safety shoes			
3	Wears uniforms			
4	Wears safety gloves when needed			
5	Wears safety masks when needed			
6	Wears safety glasses when needed			
7	At the end of shift, checks the equipment dipped into mercury			
8	After reconnecting the hoses, checks the connections			
9	Not touch the air cylinders with oily hands			
10	Stands at the right place while working with an apparatus			
11	Checks all electrical connections, before every repair of an apparatus			
12	Coordinates the Permit with the operator of apparatus			
49	Checks the chemical lines, timely			

B.2. Examples of the items presented in the environmental checklist

Environmental checklist						
Examples of the items		Good	Moderate	Weak	Irrelevant	Description
Education						
1	Employees have been specially trained based on their operation					
2	Employees have been trained to use personal protective equipment					
First aids						
5	First aids package has been installed in the workplaces					
6	Safety showers have been installed in the workplaces					
Safety of machinery						
15	There is a written action plan (Lock Out/Tag Out) for repairs					
16	All the machines are inspected daily					
Fire extinguishing						
25	Fire extinguishers are enough provided at work					
26	Fire extinguishers are properly tagged and easily accessible					

(*continued on next page*)

Examples of the items presented in the environmental checklist (*continued*)

Environmental checklist					
Examples of the items	Good	Moderate	Weak	Irrelevant	Description
Discharge guidelines					
33 Emergency exit doors are clearly marked					
34 Emergency exit boards are installed					
Chemicals					
40 A written action plan to monitor the risk is installed in place					
41 The MSDS of all the hazardous chemicals are available at workplace					
Safety of electrical installations					
44 All the electrical appliances and equipment are intact					
45 Earth wire is installed in the factory					
Record and associated workshop					
56 A written program is provided to record the activities in the workshop					
57 Workshop is regularly cleaned					
Health facilities					
65 The workplace and dining room are separated from each other					
66 Healthy drinking water is available					
Scaffolds					
71 Appropriate connections have been used for setting up the scaffolds					
72 The scaffolds are properly restrained					
Pressure cylinders					
75 There is no corrosion on the body of pressure cylinders					
76 There are appropriate caps for the pressure cylinders during transportation					
Steam boilers					
79 Steam boilers are situated in a location separated from other buildings					
80 There is no inflammable material around and above the steam boilers					
Lighting					
88 The factory uses artificial lighting					
89 The amount of lighting in the workplace has been regularly measured					
Vibration & voice					
92 The intensity of voice is not over than threshold limit value (85db)					
97 The rate of vibration has been measured in the workplace					
Atmosphere of workplace					
100 There is thermal sensors in the workplace					
101 The air pollutants of the workplace has been regularly measured					
Ergonomics					
104 The coloring of devices, equipment and walls are appropriate to prevent dazzling and reflection					
105 Chair is provided to conduct the works that needs sitting down					
Management					
112 The commitment to safety rules is clearly defined in the visions and missions of the company management					
113 The policies of management regarding safety promotion of the factory have been annually reviewed and revised					

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